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ARSENIC IN DRINKING WATER

Town of Rayside-Balfour
(Chelmsford)

April 1980



Ontario

Ministry
of the
Environment

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ARSENIC IN DRINKING WATER

TOWN OF RAYSIDE-BALFOUR

(CHELMSFORD)

April 1980

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Ministry of the Environment
Northeastern Region
Sudbury, Ontario

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SUMMARY

In August 1979, an investigation was commenced to determine the source and extent of the elevated arsenic levels in potable wells in the Chelmsford area.

In the survey, one hundred and thirty-four wells were sampled to March 1, 1980. It was found that 12 contained arsenic concentrations between 0.01 mg/L and 0.05 mg/L. Four (4) were found to contain arsenic concentrations greater than 0.05 mg/L. The Ministry's Desirable Criteria is less than 0.01 mg/L, and 0.05 mg/L is the Maximum Criteria, or Rejection Limit.

Notwithstanding the above criteria, a limit of 0.005 mg/L has been proposed to identify wells in need of correction, taking into account potential seasonal fluctuations of the arsenic concentrations. This results in the inclusion to date of a further eight (8) wells, for a total of twenty-four (24) wells, in the recommended correction program.

The arsenic in the groundwater was determined to be naturally occurring in the bedrock in the Sudbury Basin. Recommendations are presented concerning the provision of alternative water supplies to the affected residences and concerning further sampling to determine if other areas of the Sudbury Basin are affected.

RECOMMENDATIONS

The following recommendations are presented.

1. Alternative water supplies should be developed for all wells which contain arsenic above 0.005 mg/L. This can be accomplished by:
 - a) Haulage of potable water.
 - b) Providing new or sharing existing good quality wells low in arsenic concentration.
 - c) Extending the watermain from Chelmsford to the area.
 - d) A combination of (b) and (c), such as the extension of the watermain to service part of Joannette Road and the provision of new or the sharing of existing good quality wells for the rest of the affected residences.
2. The Ministry, as part of its existing well inspection program, should insist on the collection of water samples for arsenic analysis from all new drilled wells in the Sudbury Basin.

3. All existing individual residential water supplies in the Sudbury Basin should be sampled for arsenic. This sampling will be scheduled in accordance with Ministry sampling/analysis capabilities.

The sampling program priorities and emphasis should be determined by a committee established by the Regional Municipality of Sudbury which would include representation from the Sudbury and District Health Unit and the Ministry of the Environment.

4. The appropriate road authorities should be notified of the residences which appear to be affected by road salting operations.

BACKGROUND

In 1978/79, this Ministry's Technical Support Section, Northeastern Region, conducted a survey of Ministry of Transportation and Communication patrol yards to gather groundwater quality data with respect to the effects of salt storage practices. When the results of the samples collected from the well at the patrol yard near Chelmsford were examined, the arsenic concentration of the water was found to exceed the Ministry's desirable criteria (0.01 mg/L). It was however, below the Ministry's maximum allowable criteria (0.05 mg/L).

In late August of 1979, further water sampling of private wells at homes near the patrol yard was conducted to follow-up on this apparent anomaly. Several of these samples contained concentrations of arsenic which exceeded both the desirable and maximum criteria.

Immediately following the receipt of the results of the sampling for confirmation of this phenomenon, a meeting was held with representatives of the Town of Rayside-Balfour, the Regional Municipality of Sudbury (R.M.O.S.), and the Sudbury and District Health Unit, on November 2, 1979 at the municipal building in Azilda. During this meeting, analysis results were presented which confirmed the presence of elevated arsenic levels in the groundwater.

The problem was subsequently discussed at the M.O.E./R.M.O.S. Liaison Committee meeting of November 30, 1979 and an interim report submitted at the next meeting on February 18, 1980.

Throughout the program, as data became available, homeowners whose well water contained arsenic in concentrations of 0.01 mg/L or greater were advised by this Ministry not to drink or cook with their water.

DRINKING WATER OBJECTIVES FOR ARSENIC (As)

The toxicity of arsenic has been known for a long time. A number of disorders have been associated with the intake of arsenic in drinking water, but the lowest concentration at which symptoms develop has not been clearly established. There is, however, no evidence of any illness associated with the ingestion of water containing arsenic up to the Ministry's maximum acceptable concentration, 0.05 mg/L.

Some studies have suggested that arsenic is either a carcinogen or co-carcinogen, and it is therefore advisable that the level of arsenic in drinking water be as low as possible. Except in areas close to natural, agricultural, or industrial sources of arsenic contamination, arsenic is usually present only at very low concentrations in ground/surface waters.

This Ministry, in its publication Water Management in Ontario, has set the following criteria for arsenic in drinking water.

a) Desirable Criteria

Arsenic concentrations should not exceed 0.01 mg/L unless no other suitable supply is available.

b) Maximum Criteria (rejection limit)

Arsenic concentrations above 0.05 mg/L shall constitute grounds for the rejection of the water supply.

SAMPLING PROGRAM

Although the water sampling program is on-going, this report presents all of the data available as of March 1, 1980 for the following areas:

- 1) Hwy. 144 - Azilda to Chelmsford
- 2) Hwy. 144 - Whitson River to Nickel Basin Road (NBR)
- 3) Joannette Road
- 4) Bradley Road
- 5) Nickel Basin Road - Hwy. 144 - Whitson River
- 6) LaVallee Road
- 7) Genereux Street

The sampling program data are provided in summary form in Tables I, II, III, and IV. Special data for each area are presented in Tables IV(a) - IV (g), (appended).

Table I

Samples Collected to Date

No. of Residences Sampled	127
No. of Secondary Water Supplies Sampled	7
No. of Confirming samples collected	<u>36</u>
Total No. of Samples Collected	170

Secondary water supplies are those which serve only outbuildings such as barns, garages, etc.

Table II

Wells with Arsenic Concentrations
between 0.01 and 0.05 mg/L

<u>Location</u>	<u>No. of Wells</u>	<u>No. of Confirming Samples Collected To Date</u>
Hwy. 144 Azilda-Chelms.	0	0
Hwy. 144 Whitson River/NBR	2	6
Joanette Street	2	9
Bradley Road	1	4
Nickel Basin Road (NBR)	7	12
LaVallee Road	0	0
Genereux Street	0	0

Table III

Wells with Arsenic Concentrations
above 0.05 mg/L (Rejection Limit)

<u>Location</u>	<u>No. of Wells</u>	<u>No. of Confirming Samples Collected To Date</u>
Hwy. 144 Azilda-Chelms.	0	0
Hwy. 144 Whitson River/NBR	1	1
Joanette Road	3	10
Bradley Road	0	0
Nickel Basin Road (NBR)	0	0
LaVallee Road	0	0
Genereux Street	0	0

Table IV

Tables of Well Type and Arsenic Concentration

<u>Well Type</u>	<u>Arsenic Concentration</u> <u>Range</u> <u>(mg/L)</u>	<u>No. of</u> <u>Wells</u>	<u>% of Well</u> <u>Type</u>
Dug Well	< 0.001	3	19
	0.001	8	50
	0.0011 - 0.0049	3	19
	0.005 - 0.0099	2	12
	0.01 - 0.05	0	0
	> 0.05	0	0
	Total	16	
Points	< 0.001	24	50
	0.001	9	19
	0.0011 - 0.0049	10	21
	0.005 - 0.0099	0	0
	0.01 - 0.05	5	10
	> 0.05	0	0
	Total	48	
Drilled Wells Finished in Bedrock	< 0.001	7	16
	0.001	2	5
	0.0011 - 0.0049	20	47
	0.005 - 0.0099	4	8
	0.01 - 0.05	6	14
	> 0.05	4	8
	Total	43	
Well Type Unknown	< 0.001	7	26
	0.001	7	26
	0.0011 - 0.0049	10	37
	0.005 - 0.0099	2	7
	0.01 - 0.05	1	4
	> 0.05	0	0
	Total	27	

SAMPLE RESULTS

1) Arsenic

The arsenic concentrations ranged from < 0.001 mg/L to 0.14 mg/L. Wells with arsenic concentrations below 0.005 mg/L represented 82% (110) of all the samples collected. Six percent (8) of the arsenic concentrations were between 0.005 - 0.01 mg/L, and 12% (16) above 0.01 mg/L.

A drilled well finished in bedrock appears to have the greatest potential for containing water with elevated natural arsenic concentrations (22% $> .01$ mg/L) as indicated in Table IV. Points have a lesser potential for containing water with elevated natural arsenic concentrations (10% $> .01$ mg/L) than drilled wells; however, a greater potential than dug wells (0% $> .01$ mg/L).

2) General Water Quality

The water quality of the samples collected from water supplies in the sampling area is generally considered poor due to the wide distribution and elevated levels of the following chemical and physical parameters: iron, manganese, sodium, chloride, nitrate, hardness, dissolved solids, colour, and turbidity.

Elevated sodium levels were found in the water samples from 37 residences in the survey area. Sodium may aggravate hypertension and complicate heart disease. Those people placed on a salt-free diet should limit their intake of

water containing an excessive concentration of sodium. Although no official Ministry criteria exists for sodium, the Sudbury and District Health Unit is notified when the sodium concentration in a well supply exceeds 20 mg/L.

When elevated levels of sodium and chloride are found together their source may be attributed to road salting operations. In this survey it was found that 12 wells contained sodium and chloride concentrations which may be attributed to road salting operations. In addition, 25 wells contained elevated sodium due to the operation of water softeners.

Chloride is not considered a health hazard. It will, however, impart a salty taste to the water making it undesirable for drinking purposes.

Almost all wells sampled contained iron, manganese, colour and turbidity which exceeded this Ministry's criteria. These parameters are considered as aesthetic nuisances and not health hazards and can be reduced in the water through the use of ion exchange units and other water treatment equipment. Iron and manganese may cause the water to be red or orange coloured and will stain or discolour clothes, laundry or plumbing fixtures.

SUSPECTED SOURCES

The following have been considered as possible sources of the arsenic found in the groundwater.

- a) Agricultural use of chemicals.
- b) Mining operations.
- c) Smelting operations.
- d) Natural sources.

a) Agricultural Use of Chemicals

In previous years, arsenic compounds were used as a component of herbicides and pesticides and might have been used by the sod farming operations in the area.

Discussions were held with sod farmers in the survey area. Information was obtained about the chemicals used in their operations, especially herbicides and pesticides. Information was also obtained on their method of operation, when the various fields were put into production, when chemicals were used and at what rates.

It was determined that sod farmers use only a herbicide called Killex. This chemical contains no arsenic compounds and has been in use by sod farms, golf courses etc. for a considerable length of time. None of the sod farmers reported using pesticides.

In view of the above information the sod farms have been eliminated as a source of arsenic.

b) Mining Operations

Several old mines, which have been closed since about 1955 are located to the south and west of the study area. Investigations were carried out to determine if the mining operations could be the source of the arsenic. This possibility has been eliminated based on an evaluation of groundwater movement in the area. The Whitson River acts as a barrier to the movement of groundwater towards the study area.

c) Smelter Operations

The smelters of both INCO Limited and Falconbridge Nickel Mines Limited emit small amounts of arsenic compounds and have been investigated as potential sources. The apparent localized non-homogeneous (scattered) distribution of the problem would appear to indicate that these smelter emissions could not have contributed to the elevated arsenic levels in the groundwater system. Therefore, this source has been eliminated.

d) Natural Sources

The factors which are relevant to consideration of this source are:

- 1) The random distribution of the elevated arsenic concentrations.
- 2) The highest arsenic concentrations are found in wells finished in bedrock although not all bedrock wells exhibited high arsenic concentrations.
- 3) The sampling and analysis of some rock outcrops in the vicinity confirmed the presence of arsenic mineralization.

From these factors, it is apparent that the arsenic found in the ground water is naturally occurring.

WATER SUPPLY CORRECTION ALTERNATIVES

As a result of the meeting of November 2, 1979, homeowners who were notified by the Ministry were directed to obtain their drinking water from the Chelmsford municipal supply or from neighbors whose well water contains arsenic concentrations below the desirable criteria (0.01 mg/L) as an immediate solution. However, the carrying of water for drinking and cooking purposes is not generally considered to be an acceptable long-term solution.

Therefore, the following are proposed as other possible alternatives for correction of the elevated arsenic concentration problems in the affected wells scattered throughout the sampling area:

1. Extending a watermain from Chelmsford.
2. The installation of water treatment equipment.
3. The sharing of good quality wells or the provision of new wells.

Due to possible seasonal fluctuations and limited data on the arsenic concentration in the groundwater, it is suggested that all ground water supplies which contain arsenic concentrations above 0.005 mg/L be considered in any remedial works program. This means that twenty-four (24) residences should be considered for this program based on the data available as of March 1, 1980.

A more detailed discussion for each of these water supply alternatives follows:

1) Extension of the Watermain from Chelmsford

To provide a piped water system which would service all the residences with high arsenic concentrations, the watermain would have to be extended along Joannette to Bradley Road, Nickel Basin Road, and along Highway 144. This would be very costly and may require consideration of zoning redesignation to justify the expense of servicing this area (presently a non-growth area).

In the area of the junction of Joannette Road and Highway 144, the highest concentrations of arsenic have been found. This area has seven (7) wells which contain arsenic above the desirable criteria of 0.01 mg/L and all four wells which are above the rejection criteria of 0.05 mg/L. If the watermain was extended to service the strip development along the northern portion of Joannette Road, all of these water supply problems could be corrected. This would eliminate the problem of attempting to find a source of water which contains low concentrations of arsenic in sufficient quantities to supply affected residences in this area, where the highest concentrations of arsenic exists.

2) Individual Water Treatment Systems

The suitability of the following treatment methods to

remove or reduce the arsenic concentration found in well water has been investigated:

- a) Reverse osmosis
- b) Lime precipitation
- c) Carbon filtration
- d) Anionic exchange

In general, treatment for obtaining a potable water supply creates secondary problems. All the systems will require some backwashing of the treatment equipment. This would produce a wastewater containing arsenic at a higher concentration than found in the groundwater. Therefore, this wastewater must be hauled for disposal since its discharge to the shallow aquifer would likely cause further contamination. In addition, all systems will require frequent inspection and maintenance.

For this reason individual water treatment systems are not recommended for arsenic removal.

3) Sharing of Existing Good Quality Wells,
or the Provision of New Wells

This would appear to offer the most desirable solution to the problem in view of the widespread non-homogeneous distribution of the affected wells. In all cases (except for the intersection of Joannette Road and Highway 144) wells with elevated arsenic

concentrations are bounded by non-affected wells. Hence, it appears that uncontaminated groundwater is potentially available as a solution to the problem.

In all areas, however, a detailed investigation of the groundwater system and existing wells would be required before the feasibility of this alternative can be fully appreciated.

CONCLUSIONS

Based on this investigation, the following have been determined:

- 1) There are 24 residential wells in the geographical area covered by this report which contain arsenic concentrations above the recommended correction criteria of 0.005 mg/L.
 - a) Twelve (12) wells contain arsenic concentrations between the Ministry's criteria of 0.01 and 0.05 mg/L. These wells are scattered throughout the survey area.
 - b) Four (4) wells contain arsenic concentrations above the 0.05 mg/L, the maximum criteria. These wells are concentrated near the intersection of Joannette Street and Highway 144.
- 2) The source of arsenic in the groundwater is the result of naturally occurring mineralization.
- 3) a) Drilled wells finished in bedrock appear to have the highest potential for naturally elevated arsenic concentrations. Thirty percent (30%) of all drilled wells contained arsenic above 0.005 mg/L. Hence, the use of drilled wells finished in bedrock as a primary indication of the potential for elevated arsenic problems in any follow-up or exploratory area sampling program should be considered.

- b) Overburden wells appear to be less susceptible to naturally elevated arsenic concentrations.
-
- 4) In keeping with the nature of the source of the elevated arsenic levels (ie. mineralization) and the occurrence of these mineral types throughout the Sudbury Basin, there is potential for elevated naturally occurring arsenic concentrations to be found in well water throughout the Sudbury Basin.

APPENDICES

The following Tables give the breakdown of the arsenic concentrations by thoroughfare.

Table IV (a)

Highway 144 Azilda - Chelmsford

<u>Well Type</u>	<u>Arsenic Concentration</u> <u>Range</u>	<u>No.</u>
Dug Well	< 0.001	0
	0.001	0
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Points	< 0.001	9
	0.001	1
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Drilled Wells Finished in Bedrock	< 0.001	1
	0.001	0
	0.0011 - 0.0049	1
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Unknown	< 0.001	1
	0.001	1
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0

Table IV(b)

Bradley Road

<u>Well Type</u>	<u>Arsenic Concentration</u> <u>Range</u>	<u>No.</u>
Dug Well	< 0.001	0
	0.001	1
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Points	< 0.001	3
	0.001	0
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	1
	> 0.05	0
Drilled Wells	< 0.001	0
	0.001	1
	0.0011 - 0.0049	1
	0.005 - 0.0099	1
	0.01 - 0.049	0
	> 0.05	0
Unknown	< 0.001	0
	0.001	0
	0.0011 - 0.0049	1
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0

Table IV(c)

Joanette Road

<u>Well Type</u>	<u>Arsenic Concentration</u> <u>Range</u>	<u>No.</u>
Dug Well	< 0.001	0
	0.001	0
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Points	< 0.001	3
	0.001	1
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Drilled Wells Finished in Bedrock	< 0.001	2
	0.001	0
	0.0011 - 0.0049	2
	0.005 - 0.0099	1
	0.01 - 0.049	1
	> 0.05	4
Unknown	< 0.001	0
	0.001	3
	0.0011 - 0.0049	2
	0.005 - 0.0099	1
	0.01 - 0.049	0
	> 0.05	0

Table IV(d)

Highway 144 - Whitson River - Nickel Basin Road

<u>Well Type</u>	<u>Arsenic Concentration</u> <u>Range</u>	<u>No.</u>
Dug Well	< 0.001	3
	0.001	7
	0.0011 - 0.0049	1
	0.005 - 0.0099	2
	0.01 - 0.049	0
	> 0.05	0
Points	< 0.001	2
	0.001	0
	0.0011 - 0.0049	1
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Drilled Wells Finished in Bedrock	< 0.001	1
	0.001	0
	0.0011 - 0.0049	5
	0.005 - 0.0099	1
	0.01 - 0.049	1
	> 0.05	1
Unknown	< 0.001	1
	0.001	0
	0.0011 - 0.0049	3
	0.005 - 0.0099	0
	0.01 - 0.049	1
	> 0.05	0

Table IV(c)

Nickel Basin Road

<u>Well Type</u>	<u>Arsenic Concentration Range</u>	<u>No.</u>
Dug Well	< 0.001	0
	0.001	0
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Points	< 0.001	0
	0.001	2
	0.0011 - 0.0049	4
	0.005 - 0.0099	0
	0.01 - 0.049	5
	> 0.05	0
Drilled Wells Finished in Bedrock	< 0.001	1
	0.001	1
	0.0011 - 0.0049	10
	0.005 - 0.0099	1
	0.01 - 0.049	2
	> 0.05	0
Unknown	< 0.001	1
	0.001	1
	0.0011 - 0.0049	1
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0

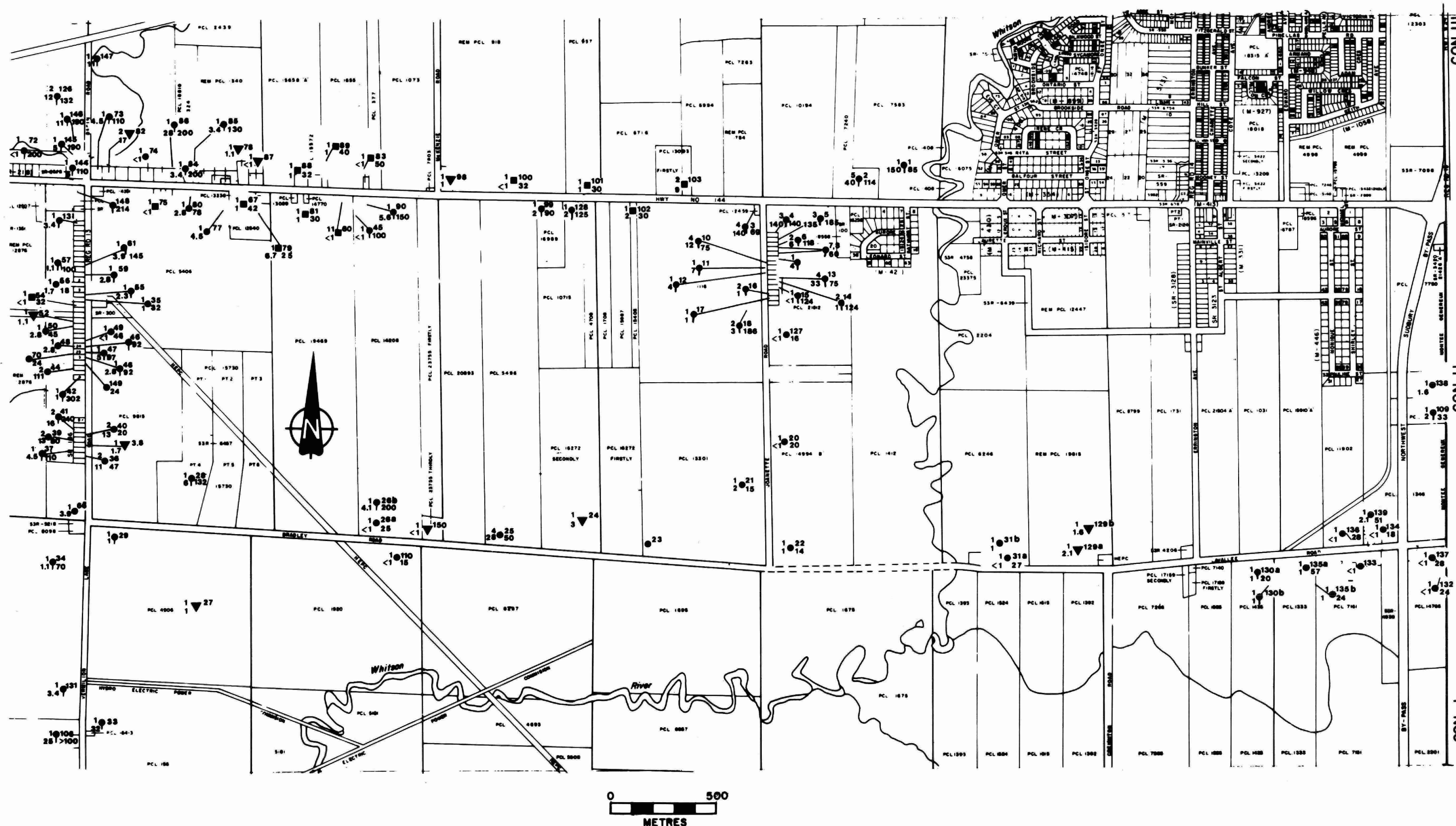
LaVallee Road

<u>Well Type</u>	<u>Arsenic Concentration</u>	<u>No.</u>
Dug Well	< 0.001	0
	0.001	0
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Points	< 0.001	3
	0.001	4
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Drilled Wells	< 0.001	0
	0.001	0
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Unknown	< 0.001	1
	0.001	1
	0.0011 - 0.0049	2
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0

Table IV(q)

Unknown or Genereux

<u>Well Type</u>	<u>Arsenic Concentration</u>	<u>No.</u>
Dug Well	< 0.001	0
	0.001	1
	0.0011 - 0.0049	0
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Points	< 0.001	2
	0.001	0
	0.0011 - 0.0049	5
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Drilled Wells	< 0.001	3
	0.001	0
	0.0011 - 0.0049	2
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0
Unknown	< 0.001	1
	0.001	1
	0.0011 - 0.0049	2
	0.005 - 0.0099	0
	0.01 - 0.049	0
	> 0.05	0



LEGEND

- DUG WELL
- WELL POINT
- ⦿ DRILLED WELL INTO BEDROCK
- ▼ WELL TYPE UNKNOWN

5 2
40 114

EXAMPLE : DRILLED WELL, 114 FT DEEP, AT LOCATION
NUMBER 2, SAMPLED 5 TIMES WITH THE HIGHEST
CONCENTRATION OF 40 µg/l ARSENIC.

MINISTRY OF THE ENVIRONMENT

INVESTIGATION OF ARSENIC
IN DRINKING WATER
CHELMSFORD, ONTARIO

SCALE: AS NOTED

DRAWN BY: J.B.M.

DATE: APRIL 1980

CHECKED BY: R.H

DRG N°: 9360



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